NATURAL RESOURCES

INACTIVE AND ABANDONED MINE LANDS— Azurite Mine, Whatcom County, Washington

by Fritz E. Wolff,
Donald T. McKay, Jr.,
and David K. Norman

WASHINGTON
DIVISION OF GEOLOGY
AND EARTH RESOURCES

Open File Report 2002-3
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site location

WASHINGTON STATE DEPARTMENT OF
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INTRODUCTION

Presently in Washington State there is no systematic database of inactive and abandoned metal mines (Norman, 2000). Previous work by the Department of Natural Resources (DNR) has had a distinctly commodity-oriented focus (Huntting, 1956; Derkey and others, 1990). The current goal is to build a single database and geographic information system (GIS) coverage of major mines in the state. Documentation will focus on physical characteristics and hazards (openings, structures, materials, and waste) and water-related issues (acid mine drainage and/or metals transport). Accurate location, current ownership, and land status information will be included. Acquisition of this information is a critical first step in any systematic approach to determine if remedial or reclamation activities are warranted. Open-File Reports (OFRs) will provide written documentation on mines or groups of mines within specific mining districts or counties.

Over 3800 mineral properties have been located in the state during the last 100 years (Huntting, 1956). Many are undeveloped prospects of little economic importance. Therefore, in considering the population to include in the Inactive and Abandoned Mine Land (IAML) inventory, we have identified approximately 60 sites that meet one of the following criteria: (a) more than 2000 feet of underground development, (b) more than 10,000 tons of production, (c) location of a known mill site or smelter. This subset of sites includes only metal mines no longer in operation.

We have chosen to use the term *inactive* in the project's title in addition to the term *abandoned* because it more precisely describes the land-use situation regarding mining and avoids any political or legal implications of surrendering an interest to a property that may re-open with changes in economics, technology, or commodity importance.

Creation of the state-managed IAML database is a cooperative effort between DNR, the U.S. Forest Service (USFS), the U.S. Bureau of Land Management (BLM), the U.S. Environmental Protection Agency (EPA), and the Washington Department of Ecology (DOE). DNR's Division of Geology and Earth Resources (DGER) is the lead agency. To date, USFS contracts have been the principal source of funding, with other contributions coming from DNR and EPA.

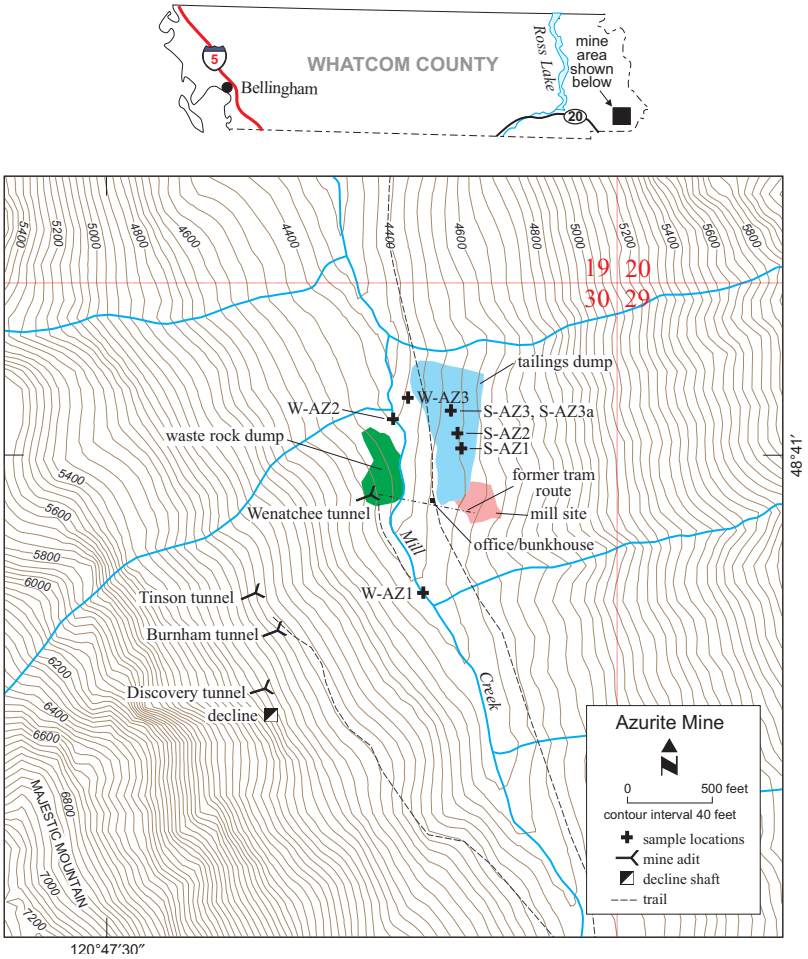

Figure 1. Map showing general location of the Azurite mine in Whatcom County and a site map of the Azurite mine.

SUMMARY

The Azurite mine lies in a remote U-shaped glacial valley in the Okanogan–Wenatchee National Forest (Fig. 1). The mine openings and ore deposit occur on the west bank of Mill Creek, a tributary to Canyon Creek and the Ross Lake reservoir. The mill site and tailings lie directly east of the mine dump on the opposite bank of Mill Creek. Access to the site in E½ sec. 30, T37N R17E is by road from Mazama to Hart's Pass, thence down Slate Creek Road to the beginning of a former mine access road near the confluence of the north and south forks of Slate Creek. The mine lies 8.5 miles distant along this route, which crosses Cady Pass at elevation 6000 feet. The terrain surrounding the mine property is precipitous. Avalanches and winter snows preclude access by land from mid-October to mid-June (Eskridge, 1937). Elevations at the Azurite mine range from 4400 to 7700 feet above mean sea level.

Charles H. Ballard, Hazzard Ballard, and Dick McLean located the deposit in 1916 and formed the Azurite Copper Co. largely on the basis of abundant chalcopyrite at the discovery site. As a result of further development, it became apparent that gold was the main commodity, prompting a name change to Azurite Gold Co. in 1925. Less than 1200 tons of ore were shipped until 1934 when American Smelting and Refining Co. (AS&R) leased the property. The company constructed a cyanide precipi-

tation mill, a cable suspension bridge, and a 700-foot aerial tramway across Mill Creek to facilitate production. Production ceased in February 1939. AS&R terminated the lease in 1940, but Azurite Gold Co. continued underground exploration work until 1941 when the War Production Board issued order L-208 shutting down "non-essential industries". Combined production receipts totaled $972,000 in gold from 72,700 tons of ore. In 1942, Azurite Gold Co. dismantled all mine and milling equipment. The mill building was destroyed by fire in 1949 (Moen, 1969). An overview of the site shows some of the features discussed in this report (Fig. 2).

None of the original group of 42 claims was patented. Azurite Gold Co. maintained corporate registration with the Secretary of State until the corporation was dissolved in September 1990. As of 2002, Gray Investments *dba* Double Dragon Exploration held five unpatented claims on *active* status in sec. 30. DGER personnel visited the site on 18 August 2001.

Gold values occur in a series of four sulfide-bearing veins that crop out on the steep eastern flanks of Majestic Mountain. Only the Azurite vein was mined. It ranged from 3 inches to 7 feet in width. The sulfide-rich portions of the vein contained an average grade of 0.385 ounces per ton of gold, however considerable drifting was done along the vein's strike in barren quartz. The Azurite vein has been mined for a vertical distance of 819 feet beneath its outcrop and explored 1070 feet along strike. Mineralization is localized along faults and contains small amounts of galena, chalcopyrite, sphalerite, and arsenopyrite in a quartz/calcite gangue. The highest gold assays were obtained from pyrrhotite-rich ore lenses (Moen, 1969). The host rock is siliceous argillite, a member of the Cretaceous Virginian Ridge Formation (Stoffel and McGroder, 1990).

The greatest physical hazard encountered at the site occurs at an elevation of 5220 feet where an inclined raise intersects the surface at the top of an underground stope. Its floor slopes downward at an angle of 47 degrees to the 250 foot sublevel and possibly beyond (Fig. 3). Horizontal openings below this raise consist of the Discovery tunnel (Fig. 4), Burnham tunnel, Tinson tunnel, and Wenatchee tunnel (in descending order of elevation). The Wenatchee tunnel became the main haulage level. It is covered by colluvium slough except for a 24 by 16 inch opening (Fig. 5). It intersected the north–south trending Azurite vein 1800 feet from the portal in 1935. Four sublevels within the mine were driven at 100-foot intervals below the Tinson tunnel. They are identified as the 350, 450, 550, and 650 levels (DGER mine map file). Another sublevel, the 1050, was opened 150 feet beneath the Wenatchee tunnel in a last-ditch effort by Azurite Gold Co. to develop additional reserves in 1940. Ore broken in the 45-degree-dipping shrinkage stopes was transferred to the '77 Raise', which connected all production workings. Detailed maps showing the extent and dates of underground development are available in DGER mine map files.

Figure 2. Overview of site, looking to the northeast. Mill Creek flows downstream from right to left. Photo was taken from access road near Discovery tunnel.

Figure 3. Vent opening at the top of the stope. View is down-dip 45 degrees. Water is dripping inside.

No hazardous materials were discovered during site characterization by DGER. The lone remaining structure on the property is a corrugated-steel-clad wooden building standing on the east bank of Mill Creek opposite the Wenatchee tunnel adit. It appears to have been used as a combination bunkhouse and office (Fig. 6). The interior is in a poor state of repair. All traces of the mill are gone except the concrete footings, a stripped-down diesel engine, burned timbers, and scrap iron (Fig. 7). An empty 10,000 gallon diesel storage tank, headworks, and buckets from the aerial tramway and miscellaneous pneumatic drill parts lie near the Wenatchee tunnel portal.

Dumps from openings driven prior to the AS&R lease are of minimal size and quantity. However, the waste rock dump adjacent to the Wenatchee tunnel haulage level covers 1.94 acres. We estimate the volume to be about 5000 cubic yards. The waste rock is heavily iron stained. A channel sample taken across the

Note: Elevations shown in this report are based on the current USGS datum for the area. Therefore, a '+60 feet' correction should be added to determine true elevations for features shown on company maps or reports based on those maps (such as Moen, 1969).

dump's slope analyzed 47 percent iron and exhibited values of arsenic and copper that exceeded values listed for "Unrestricted Use" in WAC 173-340-900 (Model Toxics Cleanup Act) by factors of 190X and 12X respectively. High water during spring runoff has eroded the dump highwall leaving an undercut face 30 feet high (Fig. 8). Tailings on the east side of Mill Creek have oxidized to a bright orange and support sparse communities of silver fir, alder and grasses (Fig. 9). Erosion and downslope movement of tailings material is minimal due in large part to *in situ* cementation. Soil samples taken below the oxidized horizon exhibited widely varying values for arsenic, copper, and lead, all of which exceeded the above WAC standard. A U.S. Bureau of Mines-sponsored study of the tailings by Harding-Lawson Associates (1980) found an average of 0.071 ounces per ton of gold in samples from five drill hole locations. Based on their estimate of 41,000 tons of tailings, the dump contains approximately 3000 ounces of unrecovered gold. A grab sample taken by DGER from the tailings contained 43 milligrams per kilogram of gold (1.25 ounces per ton), determined by the inductively coupled plasma method.

The only opening-related water discharge flowed from the Tinson tunnel at approximately 10 gallons per minute. This water infiltrated the adjacent waste rock dump. Samples taken upstream and downstream of the mine site showed no detectable levels of arsenic, copper, lead, or zinc. However, the practical quantitation limit chosen by the analyzing laboratory was 100 milligrams per liter, meaning that only analyte levels above that concentration would have been detected (see Table 6). A sample taken from a seep below the tailings had a pH of 4.7 and concentrations of copper and zinc that exceeded the standards in WAC 173-201A for aquatic life in surface freshwater, chronic level maximums. The water, flowing at less than one-half gallon per minute, infiltrated the roadside within a few feet of the seep.

A sample taken at the confluence of Canyon Creek and Ruby Creek, 9 miles downstream from the mine, showed no detectable amounts of dissolved metals at concentrations above 100 milligrams per liter.

GENERAL INFORMATION

Name: Azurite mine

MAS/MILS sequence number: 0530730040

Access: Two-wheel drive road to a gated and deteriorated mine access road.

Status of mining activity: none

Claim status: The ORMC number is the BLM designation for mining claims in Oregon and Washington. Per the Mining Law of 1872, lode mining claims fall in two categories:

1. *Unpatented claims* require a minimum annual expenditure of $100 assessment work per claim. A $100 maintenance fee may be paid in lieu of performing assessment work. Unpatented claims are classified as *active* or c*losed*. *Active* denotes a valid, up-to-date claim. *Closed* denotes that the maintenance fee, assessment work, or other requirements have not been met, and that the claim is

Figure 4. Discovery tunnel adit. Arrow points to mined-out area on Azurite vein dipping –45 degrees.

Figure 5. Wenatchee tunnel adit and tramway headworks. View to the west.

Figure 6. Bunkhouse/office built by American Smelting and Refining Co., circa 1936.

no longer valid. The following table contains information on active claims only.

2. *Patented claims* are owned in fee simple by the discoverer and their assigns. A mineral survey is performed as part of the patent application process, prior to the issuance of a patent. Some lode claims initially mined underground may at a later date turn into an open pit operation. If this occurs, a Surface Mining Permit is required, which contains certain stipulations regarding reclamation.

ORMC no.	Unpatented	Active	No. of patented claims	Mineral survey no.	Surface Mining permit no.	Source of data (date)
138389	yes	yes	none	– – –	– – –	BLM (09/01)
138393	yes	yes	none	– – –	– – –	BLM (09/01)
36750	yes	yes	none	– – –	– – –	BLM (09/01)
36754	yes	yes	none	– – –	– – –	BLM (09/01)
36757	yes	yes	none	– – –	– – –	BLM (09/01)

Current Ownership

Jos. Gray *dba* Gray Investments and Double Dragon Exploration, Corvallis, Montana.

Surrounding land ownership:
Okanogan–Wenatchee National Forest (USFS).

Location and Map Information

Mine name	County	Mine location	1:24,000 map	1:100,000 map	Decimal longitude	Decimal latitude
Azurite	Whatcom	NE¼NE¼ sec. 30, T37N R17E	Azurite Peak	Robinson Mountain	120.78106	48.68276

Directions

From Mazama on SR 20, proceed northwest past the Lost River Resort Airport to USFS road 5400, which climbs approximately 6 miles to Harts Pass. Proceed downgrade on Slate Creek Road 5.5 miles to elevation 3840 feet, just above a narrow bridge. Do not cross the bridge. At this point, follow a gated road bearing southwest. This road leads to the Azurite mine 8.5 miles distant. At one mile it crosses the south fork of Slate Creek on a deteriorating log bridge (Fig. 10). Landslides cross the road at 0.25 mile and 1.5 mile locations. The road grade averages 10 percent up to and down from Cady Pass at elevation 6000 feet. Access by foot takes approximately 6 hours, one way. The Wenatchee tunnel dump and the former mill site may provide suitable helicopter landing sites.

Mine Operations Data

Type of mine: underground

Commodities mined: gold, minor amounts of silver

Figure 7. Azurite mill site. Footings in foreground; arrow points to 400 HP diesel engine. View to the northwest.

Geologic setting: The mine lies in rocks of the Cretaceous Virginian Ridge Formation, consisting of mudstone, siltstone, and conglomerate (Stoffel and McGroder, 1990). Circular and elliptical bodies of diorite intruded these rocks during the Tertiary. Moen describes the host rock as locally a siliceous argillite. One-half mile north of the Azurite mine, argillite and quartzite have been intruded by a cupola of granodiorite (Moen, 1969).

Ore minerals: arsenopyrite (FeAsS), galena (PbS), chalcopyrite ($CuFeS_2$), sphalerite (ZnS), and pyrrhotite, (FeS)(Huntting, 1956)

Non-ore minerals: quartz (SiO_2), calcite ($CaCO_3$), pyrite (FeS_2)

Host rock: siliceous argillite

Period of production: Minor output until 1936. Major development and mill operation took place during a 1936 to 1940 lease by the American Smelting and Refining Co.

Figure 8. Wenatchee tunnel dump. Mill Creek downstream direction is toward bottom of photo. Note the undercut highwall and 10,000 gallon diesel storage tank. View to the north.

Development: About 3000 feet of adits on two levels, plus several raises connecting six sublevels and adjacent stopes. All mining took place above the Wenatchee tunnel, which served as the main haulage level at an elevation of 4440 feet above mean sea level. In 1941, a winze was sunk 150 feet below the Wenatchee tunnel level. Ore was encountered, but no stoping took place (Moen, 1969).

Production: 72,700 tons during the 1936 to 1939 period. Gross value of reported production was $972,000 (Derkey and others, 1990).

Mill data: Data in Washington Division of Geology and Earth Resources (DGER) mine files indicate that the 100 tons per day mill built by AS&R relied on a bulk gravity concentration of all sulfide minerals, followed by a sodium cyanide addition that dissolved gold and other metal values. Zinc dust added in the last step released a gold precipitate that was subsequently reduced to bricks in a small melting furnace. Ferrous sulfate was added in the barren solution tank to complex the adverse effects of sodium cyanide. Two 400-horsepower diesel engines located next to the mill generated electrical power for the entire site (*Wenatchee World*, 1938). All mill equipment has been removed. The mill building was destroyed by fire in 1949.

A mill flow sheet dated 1938 indicates that selective flotation cells were not in place to recover base metals (DGER mine file). This information indicates that the arsenic, lead, zinc, iron, and copper content in run-of-mine ore was expelled along with the sandy, –150 mesh tailings.

PHYSICAL ATTRIBUTES

Features: see Table 1

Materials: scrap iron

Machinery: Aerial tram headworks, 10,000-gallon diesel storage tank, remains of a 400-horsepower diesel engine, tram buckets, steel cable, and miscellaneous pneumatic drill parts.

Structures: see Table 2

Presence of unstable slopes, walls, waste rock, tailings, or impoundments: waste rock dump highwall above Mill Creek

Analysis of tailings and dumps: Tailings cover 5.5 acres of surface and have oxidized to a bright orange color. Borings taken by Harding-Lawson Associates (1980) show thicknesses ranging from 4 to 9.5 feet. Their report estimates a volume of 27,000 cubic yards, or approximately 41,000 tons, depending on water content.

Figure 9. Azurite mill tailings. Note the isolated communities of western hemlock and Engelmann spruce.

Figure 10. Bridge crossing the south fork of Slate Creek.

It is doubtful if any attempt was made by the lessee AS&R to create an embanked impoundment for the tailings. The tailings appear to have been dumped on a cleared portion of the slope adjacent to the mill and allowed to run downhill from a pipeline or pulled northward from the mill area by an in-line slusher and cable system. At the northwestern-most corner, thin deposits of tailings cross the access road and flow down a steep 30-foot

Table 1. Mine features. – – –, no data; **, data from DGER mine map file; *, numbered photos online at http://www.wa.gov/dnr/htdocs/ger/iaml/02-3/

Description	Condition	Fenced (yes/no)	Length (feet)	Width (feet)	Height/depth (feet)	True bearing	Elev. (feet)	Decimal longitude	Decimal latitude	Digital photo*
Wenatchee tunnel	partly open	no	1350**	8**	8**	S65W	4440	120.78165	48.6828	– – –
Tinson tunnel	open	no	1400**	5	7	S10W	4980	120.78491	48.681	2134
Burnham tunnel	caved	no	75**	– – –	– – –	S10W	4990	120.7844	48.68036	– – –
Discovery tunnel	open	no	50**	5	7	S45W	5170	120.78464	48.67941	2136–2139
unnamed opening to surface	open	no	15	8	250-foot** decline at –47° angle	n/a	5220	– – –	– – –	2140

bank to the channel of Mill Creek. This deposit is visible downstream for approximately 100 yards. A climbing rope and brush-cutting tools are required to gain access to this area.

Toxic levels of arsenic, copper, and lead were found in tailing samples taken at three different locations (Table 3). Levels for these metals correlate almost exactly with analyses reported during a U.S. Bureau of Mines contract (Harding-Lawson Associates, 1980). Iron analyses were consistently in the 100,000 milligrams per kilogram range, representing roughly 10 percent of the material present. These levels are consistent with input from the mineralization present—pyrite, pyrrhotite, arsenopyrite, galena, chalcopyrite—and input from mill reagents—ferrous sulfate, lead acetate, lead oxide, lime, and sodium cyanide.

Sample S3A was taken from a tailings layer of bluish, unoxidized sandy clay 12 inches beneath a gully surface in the central portion of the area. The sulfate analysis was 20,000 milligrams per kilogram or 2 percent of the total by weight. This result explains the presence of white-gray salts deposited on the surface at several locations (Fig. 11). When analyzed using induced coupled plasma technology, the sample yielded 43 milligrams per kilogram of gold, which equates to 1.25 ounces per ton. This result is considerably higher than the Harding-Lawson Associates (1980) data. The sample may have been taken from a volume of material deposited when the mill was out of trim. The Harding-Lawson assays, which were taken over a wider area, ranged from 0.03 to 0.142 ounces per ton gold. Their analyses were done by atomic absorption technology.

A grab sample taken of waste rock at the portal of the Wenatchee tunnel contained 470,000 milligrams per kilogram iron, or about 50 percent of the material present. The high iron content acts as the dump's cementing agent. This sample also ran exceptionally high in arsenic. At 3800 milligrams per kilogram, the arsenic level is 190X the level listed in Table 4; the copper level is 12X.

Waste rock, tailings, or dumps in excess of 500 cubic yards: yes

Reclamation activity: none

Table 2. Mine structures. – – –, no data; *, numbered photos online at http://www.wa.gov/dnr/htdocs/ger/iaml/02-3/

Description	Decimal longitude	Decimal latitude	Elevation (feet)	Condition	Digital photo*
bunkhouse/office—wood frame with galvanized steel roof and siding	– – –	– – –	4485	standing but deteriorated	2101
mill footings, concrete	120.77951	48.68247	4560	intact	2105–2107

Table 3. Soil analysis. Metal concentrations are in milligrams per kilogram. Numbers in parentheses indicate the factor by which the analysis exceeds standards shown in Table 4. – – –, no data

Sample location	Arsenic	Cadmium	Copper	Iron	Lead	Mercury	Zinc	Gold
Wenatchee tunnel dump	3800 (190X)	– – –	1200 (12X)	470,000	62	– – –	120	– – –
tailings S1	3200 (160X)	– – –	270 (3X)	150,000	410 (2X)	– – –	67	– – –
tailings S2	1400 (70X)	– – –	470 (4X)	100,000	460 (2X)	– – –	49	– – –
tailings S3	1200 (60X)	– – –	480 (5X)	100,000	340 (1.5X)	– – –	94	– – –
tailings S3A	380 (19X)	– – –	990 (10X)	100,000	280 (1.3X)	– – –	250	43

Table 4. WAC 173-340-900, Model Toxics Cleanup Act. Priority Contaminants of Ecological Concern for Sites that Qualify for the Simplified Terrestrial Ecological Evaluation Procedure. Table 749-2 partial data. Concentrations are in milligrams per kilogram. Levels shown are for unrestricted land use. Levels for silver, gold, and iron are not specified

Metals	Arsenic III	Cadmium	Copper	Lead	Mercury	Zinc
Level, mg/kg	20	25	100	220	9	270

Figure 11. Site of soil sample S3A. Note blue unoxidized horizon and white salt deposit. Plastic trowel for scale.

VEGETATION

Virtually all the tailings area is devoid of vegetation. However, sparse communities of silver fir, alder, grasses, and western hemlock have taken root in widely spaced areas around the periphery. The tree species range in size from seedlings to 3 feet in height. The tailings are highly compacted and nearly impenetrable by roots. Species growing in the general vicinity of the mine and mill sites are western hemlock, western red cedar, Engelmann spruce, mountain ash, alder, willow, and sedge. The Wenatchee adit dump is essentially barren of vegetation.

WILDLIFE

See Table 5

WATER QUALITY

Surface waters observed: Mill Creek, Slate Creek, and Chancellor Creek

Proximity to surface waters: 0 feet

Domestic use: none

Acid mine drainage or staining: None from the mine. Potential exists during spring runoff for drainage from the mill tailings.

Water sample data: see Table 6

Water sample results: see Table 7

Surface water migration: The seep below tailings pile and discharge from Tinson tunnel both infiltrate within 20 feet.

ACKNOWLEDGMENTS

The writers wish to thank Gregg Knott and Rod Lentz of the Wenatchee–Okanogan Forest (USFS) for information on location and access to the Azurite mine. Our editor Jari Roloff contributed a number of clarifying, helpful suggestions on the report, and Karen Meyers resolved some mysteries posed by the computer.

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Wenatchee World, 1938, Azurite gold mine up Methow big producer: Wenatchee World, 27 April 1938, sec. 3, p. 1, 6.

Table 5. Bat survey

Opening	Aspect	Air temp. at portal	Air flow: exhaust	Air flow: intake	Bats or bat evidence	Date of observation
Wenatchee tunnel	S40W	39°F	yes	no	no	21 August 2001
Tinson tunnel	S45W	42°F	yes	no	no	21 August 2001
Discovery tunnel stope, dips to west at –46 degrees	S70W	54°F	no	no	no	21 August 2001
incline, dips –46 degrees to west	N87W	54°F	no	slight	no	21 August 2001

Table 6. Surface water field data

Sample ID	Description	Flow (gpm)	Conductivity (μS/cm)	pH	Bed color	Temp.	Elev. (ft)
W-AZ1	Mill Creek, upstream from mine area	>500	040	5.2	natural	50°F	4485
W-AZ2	Mill Creek, downstream from mine area	>500	044	5.2	natural	48°F	4400
W-AZ3	seep at toe of tailings	<1	360	4.7	green algae	45°F	4440
W-AZ4	Canyon Creek above confluence with Ruby Creek	>1000	138	5.0	natural	53°F	1940

Table 7. Surface water analysis. Metal concentrations are in μg/L, uncorrected for hardness; hardness is in mg/L. ≤, indicates metal was not detected; the number following is the practical quantitation limit above which results are accurate for the particular analysis method—the metal could be present in any concentration up to that limit and not be detected. – – –, no data

PART 1: ANALYSIS BY USEPA METHOD 6010, INDUCTIVELY COUPLED PLASMA					
Sample location	**Arsenic**	**Copper**	**Lead**	**Zinc**	**Hardness**
Mill Creek ¼ mi. upstream from mine area	≤100	≤100	≤100	≤100	14
Mill Creek ¼ mi. downstream from mine area	≤100	≤100	≤100	≤100	15
seep at foot of mill tailings	≤100	120	≤100	290	110
Canyon Creek 7 miles below mine site, above Ruby Creek confluence. (Ross Lake tributary)	≤100	≤100	≤100	≤100	64
PART 2: APPLICABLE WASHINGTON STATE WATER QUALITY STANDARDS					
Type of standards (applicable Washington Administrative Code)	**Arsenic**	**Copper**	**Lead**	**Zinc**	**Hardness**
Surface water standards (WAC 173-201A, Standard for aquatic life in surface freshwater, chronic level maximums at 100 mg/L hardness)	190	11.4	2.5	104	100
Ground water standards (WAC 246-290, Washington State Department of Health, standards for ground water, domestic consumption)	50.0	1300	15	5000	– – –

Appendix

PHOTOGRAPHIC DOCUMENTATION

Photos (JPEG format) listed in tables and photo log may be found on our website at http://www.wa.gov/dnr/htdocs/ger/iaml/02-3/.

METHODS

We recorded observations and measurements in the field. Longitude and latitude were recorded in NAD83 decimal degree format. Literature research provided data on underground development, which was verified in the field when possible.

All water samples were collected as simple grab samples in pre-cleaned 500 mL HDPE bottles with preservative and kept on ice for transport to Sound Analytical Services, Inc. (SAS). Soil samples from dumps or tailings were taken from subsurface material and double bagged in polyethylene. Chain of custody was maintained.

Water and soil samples were analyzed for arsenic, cadmium, copper, iron, lead, and zinc by inductively coupled plasma/mass spectrometry (ICP/MS) following USEPA Method 6010. Samples were analyzed for mercury by cold vapor atomic absorption (CVAA), USEPA Method 7470 (water), and Method 7471 (soil).

Holding times for the metals of interest were observed (28 days for mercury, 180 days for other metals). Instrument calibration was performed before each analytical run and checked by standards and blanks. Matrix spike and matrix spike duplicates were performed with each set.

FIELD EQUIPMENT

Garmin GPS III+, handheld GPS unit
Litmus paper, range 0–14, and 4–7
Hanna Instruments DiST WP-3 digital conductivity meter and calibration solution
Taylor Model 9841 digital thermometer
barometric altimeter
digital camera
binoculars
flashlight